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## No. 14



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No. 14

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## PHOTOELECTRIC TECHNIQUES FOR STORING DATA

Moscow TEKHNIKA I NAUKA in Russian No 5, 1977 pp 10-11

[Article by V. Malinovskiy, director of the laboratory for holographic methods of measurement of the Institute for Automation and Electrometry of the Siberian Branch of the USSR Academy of Sciences and a candidate in physical and mathematical sciences: "For Fifth Generation Computers"]

[Text] The need to create systems for storing and processing data with qualitatively new indicators both in storage capacity and in their dynamic characteristics is obvious. The constantly growing complexity of the circuits of traditional microelectronics has forced researchers to turn to optics and new physical principles of recording for implementing systems of exceptionally large capacity, for simplifying the connections between elements at the cost of photon neutrality, and for creating operational systems with very high operating speeds.

These problems are successfully being solved in the laboratory for holographic methods of measurement of the Institute for Automation and Electrometry of the Siberian Branch of the USSR Academy of Sciences. V. Malinovskiy, director of the laboratory and a candidate in physical and mathematical sciences, tells of them.

One of the central problems which must be solved in developing new computer equipment is connected with the search for and synthesis of materials which can be used for optical recording of data. In recording data a light beam, which is modulated according to some law, acts on the material, changing its

optical characteristics (refractive index, coefficient of absorption, etc.). The read-out beam reacts to the change in the characteristics of the material and reproduces the coded data in the form of changes in the intensity or phase of the transmitted or reflected light. In fact we talking about controlling the parameters of one light beam (the read-out one) with the aid of another (the recording beam), while the information carrier (the material) is an intermediate link which makes it possible to effect the efficient interaction of two (or several) light beams.

One of the simplest means of recording is to burn openings through a thin metal film applied to a transparent subsurface. A laser beam focused to the size 1 micromil$^2$ vaporizes a part of the metal film. A series of transparent and opaque spots are formed on the surface, and certain information is encoded in the system of their alternation. This method of recording is the same as punching cards in contemporary computer equipment, but the difference is that the use of optics makes it possible sharply to increase the density of recording (up to $10^8$ bits on every square centimeter of material).

The drawback to the method of recording on metal films is obvious—all the energy outlay is placed on the light beam. This can be avoided through the use of photographic plates. The joint efforts of scientists in various specialties have led to the creation of highly perfected photographic films and plates which possess high sensitivity (approximately $10^{-5}$ Joules/cm$^2$) and good resolution power (more than 1000 lines/mm). In contrast to the preceding recording method, with the new method the requirements for the intensity of the laser beam are significantly lower, inasmuch as in the development process the image is multiplied $10^6$-$10^{10}$ times! It should be noted here that the development process is not obligatorily connected with processing the plates in special solutions. At the present time there have been developed special photosensitive compositions which are developed by a "dry" method, e.g. by heating.

There is a whole group of materials (for example, chalcogenide glass semiconductor films, certain ferroelectric crystals, oxides of transition metals) which are used in recording data by holographic methods—the recovery beam is diffracted on the alterations in the index of refraction in the contents of the hologram.

The examples presented illustrate the possibilities for creating a so-called archival memory; as a result of its interaction with light the recording material is permanently altered in either its transparency or its index of refraction.

The basic efforts of researchers in recent years have been directed toward the search for and development of materials which will permit data to be recorded and erased many times. In connection with this the following tasks arise: an explanation of the physical mechanisms for the interaction of light with a substance, an investigation of the possibility of improving the energy characteristics of the process, and a directed synthesis of materials with the required parameters. These are not simple tasks; the answers to a whole complex of questions are connected with them.

The associates of the Institute for Automation and Electrometry of the Siberian Branch of the USSR Academy of Sciences have analyzed the peculiarities of the functioning of internal data carriers, have proposed a model of an elementary internal memory cell, and have reviewed the possibilities of implementing it on continuous and discrete elements. It turned out that the optimal materials and combined structures from the standpoint of circuit engineering solutions are those at the basis of whose functioning are photoelectric energy conversions during recording and an electrooptical effect during reading. Only the data functions are dependent on the beam of light; the energy expenditures are covered by external power sources.

In the institute there is in operation an experimental model of a space-time light modulator on germanate of bismuth crystals (a continuous medium). Its sensitivity to light is $10^{-6}$ Joules/$cm^2$, as with the best photographic plates, but in distinction to them, this system permits multiple recording and erasing of an image, in addition to which the work is carried out in real time without the customary developing process.

Another experimental model which has undergone laboratory testing is a model of a discrete threshold optical element which uses a niobite of lithium crystal as the light modulator and an avalanche phototransistor as the photoelectric converter. It satisfies all the requirements for a logical unit and will be used by circuit engineers for solving several applied problems.

The obvious advantages of electrooptics in conjunction with photoelectric converters for use in operational systems have led to the necessity of formulating a number of new tasks, some of which have already been completed, while others are only in the planning stage.

As is well known, the action of laser radiation produces lasting alterations in the index of refraction in certain ferroelectric crystals. This effect, which has been given the name of the optical damage effect (ODE), is used on the one hand for recording data in crystals, but, on the other hand, it becomes an obstacle when an electrooptical crystal functions as a light modulator.

There are two models for explaining the ODE, the field and the polarization ones. The first connects the change of the index of refraction under the action of light with the separation of charges in the amount of recording and the electrical field which arises as a result of this. The second model does not propose the occurrence of a field and explains the ODE by a change in the spontaneous polarization in the illuminated section of the crystal. We have succeeded in understanding the cause of the ODE and in establishing the basic laws which explain the experimentally observed effects. This has made it possible, by changing the initial conditions, to use electrooptical crystals either to modulate light or to record optical information in the contents of the crystal.

Internal memory systems of the future can evidently be thought of as a multi-layered pie in which one of the components will be an electrooptical crystal film. Films are complex physical objects. In the Institute for Automation and Electrometry a methodology has been worked out to investiage transient processes in the films of dielectrics and numerical experiments have been carried out to expose the peculiarities of non-static processes. The dynamics of the response of a material to pulse effects from without (an electric field, light), make it possible to obtain information on the peculiarities of the internal processes with greater fullness than in static studies. The experiments have been carried out on grained niobite of lithium and silicate of bismuth films which have been received in the institute. Some of the experimental work is done with control of the process by a computer, and the data from the experiment is processed by a machine in real time.

For the fifth generation computer to become a reality, it is essential to unite the efforts of scientists of different specialties—physicists, chemists, mathematicians, etc. Work on the problem of materials is coordinated within the framework of the USSR Academy of Sciences by a special committee, Fundamental Foundations of Memory and Optical Processing of Data, under the direction of academician A. Prokhorov. In the Siberian Branch the institutes of organic chemistry, inorganic chemistry, chemical kinetics and combustion, and semiconductor physics are participating in it. The efforts of the institutes

are united by a coordinating plan for the Siberian Branch, and they are directed by Yu. Nesterikhin, deputy chairman of the committee and a corresponding member of the USSR Academy of Sciences.

PHOTO CAPTIONS

1. p 10. The Institute for Automation and Electrometry of the Siberian Branch of the USSR Academy of Sciences. A practical experiment is underway in automating scientific investigations with the aide of a multi-machine complex uniting computers, storage units, collating equipment and data processing.



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## CYBERNETICS, COMPUTERS, AND AUTOMATION TECHNOLOGY

### MINSK ORDZHONIKIDZE COMPUTER PLANT

Minsk PROMYSHLENNOST' BELORUSSII in Russian No 5, May 77 pp 45-46

[Article by V. Andreyev: "Assembly of Computers is controlled by a Computer"]

[Text] Conservatism does not vanish from engineering, even in our age of scientific and technical revolution. New forms of technically complex production appear and principles on which it is based change. One thing, however, remains unchanged - the conveyer assembly line.

The conveyers change with time, naturally. They become covered with the growth of small-scale automation equipment, change their rate of motion or cease to move altogether (the so-called free-motion conveyers have been employed in recent years, especially for assembly of instruments). The essence of labor, however, remains invariant, i.e., the principal active force and a guarantee of quality always was and still is a human being.

When the computer assembly was put on the conveyer (first time in Europe!) at the Minsk Ordzhonikidze computer plant, this was lauded as a very significant achievement. This was not without justification. The conveyer-assembled "Minsk-32" computer and ES-1020 processor received general recognition and were awarded a Mark of Quality by the state. The change to conveyer assembly had much to do with the success achieved by the plant collective during the Ninth Five-Year Plan.

Even then, however, while thinking of the future operations during the Tenth Five-Year Plan, the plant specialists observed also some disadvantages of the conveyer assembly system. These disadvantages were not only those that are commonly known ("tie" of the worker to a moving or a pulsating belt, dependence on neighbors to the right and to the left).

They discovered, first of all, that some production time loss will be unavoidably caused by individual characteristics of each worker (each has his own temperament, his own reaction, his own mobility and, consequently, his own working speed). Secondly, the conveyer assembly does not insure a stable quality. The third generation of machines (the Unified Computer System) used twist assembly, i.e., a mechanical operation. The correction of errors made during such an assembly process is a very laborious task. An assembled block was "quality tested" and a multitude of circuits had to be untwisted if errors were discovered (which was almost always). When a bad connection was made in one of the lower "levels" of the block, then "level" after "level" had to be

untwisted. After correction, the entire block was reassembled again, which did not exclude the possibility of a new error.

In shorter terms, specialists of the mechanization and automation section were assigned an apparently impossible task: to achieve an intentionally reliable assembly without lowering the productivity. They have solved this problem by not decreasing but, indeed, increasing labor productivity.

The solution of this problem required bold decisions; traditions had to be overcome and stepped over the name of efficiency and quality. In brief, the specialists refused to use the conveyer and returned to positional method of assembly, based on a radically new technique. This technique was based on semi-automatic devices, developed by the staff of the mechanization and automation section and manufactured at the plant. These devices guarantee errorless connections.

By pressing a foot pedal, an assembler sends a request to an electronic device which is controlled by perforated tape. The device responds instantly by moving a carriage above the assembled block in such a way that its indicating hole stops above a desired connection point and illuminates it with a small bulb. The wiring operator inserts her gun into the hole and executes the wire twisting operation. A request for the next wiring point is transmitted. An indicator becomes activated which determines the length and the color of the wire jumper. The operator inserts the jumper into her gun and again executes a twisting operation at the point indicated by light.

What has been achieved as a result of this?

We have an immediate improvement in four aspects, replies chief of mechanization and automation section I. Matyshev. First of all, whereas previously an operator was able to complete 1 - 2 twisting operations per minute, depending on her experience and qualifications, at the present time she is able to complete 4 - 5 such operations. This means that labor productivity in the block assembly increased by about four times. Secondly, working conditions also improved. The operator is no longer tied to her neighbors along the conveyer belt. She assembles the entire block from beginning to the end at her natural speed. This has removed the psychological pressure. The conveyer operators were required to continuously read the wiring diagram and to strain their eyes in order to find the required terminal. As a result of this, older workers with a weaker vision had to change their jobs. Now nobody is jeopardized by such a situation and it is also interesting that the operations of the semi-automatic device can be mastered during the first hour on the job. Thirdly, the electronic device continuously checks the correctness of completed connections and guarantees an assembly without errors. Finally, we have created the possibility of centralizing the control of all assembly segments in a single computer. The performance of each operator is also monitored by the machine.

I observed the master console in the shop. It continuously receives signals from every work site. The signals tell which semi-automatic equipment is

functioning and fix those that are not; they also determine how many twisting operations should be performed by a specific operator and how many were actually completed at any specific time.

So far the block assembly line uses autonomous control devices whose programs are recorded on perforated tapes. Very soon, however, the entire control will be performed by a computer and the perforated tape devices will be retained for emergency use only.

Anyway, the computer control is not something to be expected tomorrow because it is already here today. Next to the block assembly line we have a frame assembly line which is equipped by the automated assembly control system (AACS) whose "brain" is a "Minsk-32" computer. A full complement of interface equipment with all work sites has been developed.

On this portion of the assembly line the computer displays visually on an individual screen the control information requested by the operator. The display includes the "address" of the operation (number of block, joint and contact) and its character (twist or soldering). Following the delivery of address, the machine checks immediately if it was understood correctly by the executing equipment. In case of an error, the computer repeats the signal. If the operator erroneously touches the wrong contact, her gun will not operate. In addition to the visual "address", the machine will apply an electric control signal to the specified point. In this way the quality of assembly is guaranteed automatically.

At the present time the computer controls 16 frame assembly sites (at the end of the year there will be a total of 30). The adjacent section has 40 semi-automata for assembly of blocks (eight more will be added). All this will be combined into a single system whose control will be assumed by the ES-1022 machine (servicing so many work sites is simply too much for the "Minsk-32" computer). At the same time the machine will also assume responsibility for some other functions, e.g., solving the problems of work scheduling and dispatching and organization of supply flows. In this way it is planned to provide a complex mechanization of all operations.

The tasks already completed and those planned for the nearest future represent only the first step on the path of breaking with traditions. The automation and mechanization section and other services of the plant face many technical and ... psychological problems.

Let us first consider the technical problems. The new method is so far only used to assemble the ES-1022. Larger and more complicated machines ES-1035 and ES-1060 are still assembled by the old method.

The problem is that many innovations that seem convenient today may become inconvenient tomorrow (just as the conveyer). By discarding the conveyer the plant unquestionably took a step forward because the new assembly method will allow a drastic increase in efficiency of labor and in quality of products. The work was made easier but at the same time it also lost much of its contents. Let us remember the words of the MAS chief that "trainees master the operation of semi-automatic equipment during the first hour on the job".

Let us think about this phrase...

In the interaction between man and machine we usually assume that the computer will handle laborious routine thought operations, leaving to the man the creative initiative and the right to make decisions. Here, however, we have achieved a reversed situation, i.e., the machine assumes the responsibility for practically all thought operations and thus removes physical and nervous tension from the man.

This is not attractive to a human who is a thinking being (primarily !). The performed work will unavoidably cause psychological wear, perhaps not immediately but only after years (a monotonous task remains monotonous, even if a human operator holds a modern, electronically controlled instrument in her hands instead of an ordinary wrench). There will appear a conflict between the social significance of a specific job and its contents.

What is the solution? The same scientific and technical progress moving further ahead. The possibility of encounter of social and psychological problems in production should in this case be a signal for attempting to solve technical problems at a higher level. The semi-automatic devices, which require routine human efforts should be replaced by automata, controlled by highly skilled operators, who can create and make decisions, leaving to the machine its machine tasks, i.e., routine thought and purely mechanical operations.

This, however, is a task for the future. One would like to believe that this future will not take by surprise the creatively thinking staff of the G. K. Ordzhonikidze plant, who are now the leaders of their industry.



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## SCIENTISTS DISCUSS PHOTOGRAPHS TAKEN FROM SATELLITES

Moscow OGONEK in Russian No 3 1977 pp 16-17

/Interview with Yan L'vovich Ziman and Yuriy Mikhaylovich Chesnokov by Vanda Beletskaya: "The Rainbow That Is Earth"/

/Text/ This issue marks the first publication of the color photographs taken during the flight of the Soviet Soyuz-22 spacecraft. The pictures were taken with a multiband space camera that was developed jointly by specialists from the Soviet Union and the GDR. In the Soviet Union, the work was directed by the USSR Academy of Sciences' Institute of Space Research. Our correspondent, Vanda Beletskaya, met with two coworkers from the institute: Yan L'vovich Ziman, head of the Department for Investigating the Earth From Space, and Yuriy Mikhaylovich Chesnokov, head of the Photographic Methods Laboratory. They were both directly involved in the preparations for the "Rainbow" experiment.

/Question/ "Life does not exist on Earth," was the conclusion reached by the American scientist Carl Sagan, who was attempting to speak from the viewpoint of a Martian looking at our planet from space. This witty warning about hasty conclusions in science came to mind when I saw the beautiful photographs taken from the Soyuz-22, at your institute. In fact, one of the "proofs" of Sagan's "hypothesis" was photographs taken from satellites that showed our planet without any traces of life on it. A joke is a joke, but it does indicate the huge difficulties that investigators must overcome when they are preparing space experiments similar to Rainbow.

Yan L'vovich, please tell us about "space" methods of studying the Earth. Are the difficulties in implementing them compensated for by their advantages?

/Ziman/ This new field -- investigating the Earth from space -- emerged comparatively recently. However, remote methods for studying distant objects have been known to scientists for a long time, although they were the monopoly of astronomers who had no other way of studying the distant worlds that are of interest to them.

From the terrestrial sciences, the geophysicists and geologists were the first to make use of remote methods. For them, the prospect of looking at our planet from space proved to be most alluring. They saw macroformations and geological faults and traced complex geological processes in a manner that is simply impossible when one is on the Earth's surface. From space, scientists discovered many fundamentally new facts about our planet. This is understandable: "One looks at large things from a distance. . ." Actually, is there any other way to look at the Earth for an entire day than from a satellite? And four satellites working together can constantly see the entire Earth and instantaneously report the information they are collecting.

Strenuous efforts to develop new methods were begun. Now, almost every TASS report on the launch of a routine satellite or spacecraft speaks of its use in investigating our planet's atmosphere and surface, the world ocean, and the depths of the earth. Information gathered in space is used by people in the most "Earthbound" professions: from geologists and geographers to specialists in agriculture and the fishing industry.

There are many methods of studying the Earth from space, and each of them adds a few new lines to the portrait of our planet.

The first cosmonauts told about the remarkable images that they saw from orbit. Although this information was subjective to a considerable extent, it did enrich our concept of the Earth. Then the scientists were given photographs from space, which literally caused a revolution in many sciences. However, Yuriy Mikhaylovich can tell you about this better than I can.

/Chesnokov/ I will add that television pictures expanded the amount of information obtained even more, while microwave and radiothermal surveying made it possible to obtain accurate data on the Earth's surface at any time of day and in any weather.

As no other method can, perhaps, photographing the Earth from space makes it possible to produce the largest amount of information, concentrated in a single frame; no receiver -- except a laser -- has such resolution.

In principle, our technology now enables us to see the same detail in space photographs as in aerial photographs. However, such equipment is not needed for our investigations. The difficulty of building it is quite high and, besides, an excess of information with a huge number of details complicates the processing of the data.

The study of the Earth's natural resources from space requires the creation of specialized photographic equipment. Thus, multiband photography was born. Space research itself demanded that it be developed. During such photography, there is simultaneous surveying of the Earth's territory in different bands of the spectrum. A series of

photographs is obtained: on each of them are visible only those elements that reflect electromagnetic waves of a certain length. And if these photographs are compared, it turns out that whatever is hidden in one picture is clearly visible in another.

/Question/ Is a section that has been photographed then subjected to "cross examination" by scientists?

/Chesnokov/ Precisely! Thus, we not only succeed in seeing geological faults and other macroformations, but are also able to distinguish rocks with different mineral compositions and obtain information about soil moisture and composition, water salinity and contamination, the degree of wave action in the sea and the presence of phytoplankton in it, and see fields sown with different crops. Surveying in the infrared band of the spectrum reveals many geological processes related to volcanic activity and can even warn us about volcanic eruptions. Is it not true that these examples speak clearly not only of the need for further study of our planet by space methods, but also of their economic profitability?

Space methods of studying the Earth are extraordinarily important for international cooperation. Geological formations and other natural phenomena are not respecters of national boundaries, of course. And such a joint study of the Earth is especially important for the socialist countries, which have the same economic and planning system.

It is possible that in the future we will see specialized surveying instruments and satellites for different purposes: some for geology, others for agriculture. Right now we have the problem of optimizing the requirements for our facilities for studying the Earth from space, in order to create a unified complex that will satisfy to the maximum extent all the users of information on terrestrial resourcements and the environment.

/Question/ The Institute of Space Research has been developing techniques for photographing the Earth from space for many years now. Yan L'vovich, which of the largest space experiments would you like to mention in this respect?

/Ziman/ First of all, the heroic work of cosmonauts Georgiy Dobrovol'skiy, Vladislav Volkov, and Viktor Patsayev on the first Salyut orbital station. Their deaths were tragic, but when the materials from their work reached Earth, they proved to be priceless for scientists and enabled them to solve many problems. In particular, a technique was worked out for obtaining highly detailed pictures of Earth from space.

Multiband surveying for the purpose of investigating the Earth's resources was conducted on the Soyuz-12 and Soyuz-13 ships. For example, the crew consisting of Vasiliy Lazarev and Oleg Makarov took about 100 photographs in different bands of the spectrum. They were

used to define more precisely the relief and nature of the underwater growth along the northeastern coast of the Caspian Sea and compile a map of soil salinity in the area of Mangyshlak and Buzachi, and also revealed promising structures for gas and oil prospecting.

On the one hand, the Rainbow experiment is a continuation of the study of the Earth's natural resources from space; on the other, it is a new stage in the development of multiband equipment for use in space.

/Question/ And how, exactly, was the Rainbow experiment set up? The scientific and technical difficulties of implementing it were probably quite large. Yuriy Mikhaylovich, how much time elapsed between the beginning and completion of the development work?

/Chesnokov/ About three years. This period is very short if you consider that the photographic equipment on the Soyuz-22 is an extremely complicated scientific complex that is loaded with electronic units. This is the shining achievement of the Rainbow experiment -- a bright success achieved through the collaboration of scientists from the GDR and the Soviet Union. Besides our Institute for Space Research and the Karl Zeiss Jena people's enterprise, the Geography Department of Moscow State University and the GDR Academy of Sciences' Institute of Electronics participated in the work.

Yan L'vovich has already said that Vasiliy Lazarev and Oleg Makarov brought back a large number of photographs made in different bands of the spectrum. They underwent careful examination and analysis. The conclusion was clear: in order to achieve even greater success in conducting the space surveys that are so important to the national economy, a better camera is needed.

The requirements for such a unique camera were extremely rigorous. It had to perform while in orbit around the Earth and withstand all the "nuisances" of spaceflight. Therefore, it had to be compact and reliable, need little energy, and work smoothly in the automatic mode.

There was also the question of how many bands of the spectrum should the new instrument be able to photograph. In our institute's laboratories we analyzed the spectral characteristics of 2,000 terrestrial formations. Only after this great work was completed did we decide to make a six-band camera. Such photographs taken from orbit would contain the information that is most useful for different areas of the national economy.

After this research was done, the Karl Zeiss Jena enterprise in the GDR started to manufacture the parts of the multiband space camera. It was called the MKF-6. It is an extremely complicated electromechanical device. And the specialists from the GDR must be given their due: once again, the Karl Zeiss Jena plant demonstrated its high technical level and the excellent training of its personnel to

the entire world. The photographic equipment's quality is up to the highest world standards.

Before the MKF-6 tooks its place in the Soviet Soyuz-22 spacecraft, however, it underwent a long cycle of testing in laboratories in the Soviet Union and the GDR. It was also necessary to create special equipment that was hardly less complex than the camera itself, in order to perform these ground tests.

For three months before the launch of the Soyuz-22, the new space camera underwent flight testing in the institute's AN-30 flying laboratory. Photographs were taken of the surface of a special test range that GDR scientists had designated for aircraft, space, and ground research. At that time, everyone was impatient to begin the tests and find out their results. The scientific leader from the Soviet Union, Doctor of Technical Sciences Yuliy Konstantinovich Khodarev, and the chief designer, Karl Muller, arrived at the airport in Erfurt at 0600 hours, when it was barely light, and the first photographs were developed right on the airplane.

/Ziman/ I would like to add that the workers in our institute labored with their colleagues from the GDR on a very friendly basis. In the laboratory, Candidate of Technical Sciences Yuriy Mikhaylovich Chesnokov was working out space photography methods, and experiments were conducted on the Soyuz-12, Soyuz-13, and Soyuz-22. Together with specialists from Karl Zeiss Jena, Boris Dunayev actively participated in the development of the multiband equipment; he was the Soviet Union's leading specialist on this matter. Vladimir Katsov was concerned with the problem of selecting the spectral characteristics. I have named only three people, but this was creative, hard work done by a large and friendly collective from our Department for Investigating the Earth From Space.

/Chesnokov/ I remember how we all impatiently awaited the launch of the Soviet Soyuz-22 spacecraft, and the moment when Valeriy Bykovskiy and Vladimir Aksenov reported to the Flight Control Center: "The camera has been turned on, and we have nothing unusual to say about its operation." Then we started to receive photographs of separate sections of the Soviet Union and the GDR.

/Question/ It has been reported that, in addition to the MKF-6, your specialists created another instrument for the Rainbow experiment -- a multiband synthesizing projector. What does it do?

/Chesnokov/ The multiband synthesizing projector is needed to analyze the space photographs. It makes it possible to combine them in all sorts of different combinations. The photographs are more or less infused with pigments and, by changing the tint, the most diversified information about the photographed section of the Earth is produced for the scientists. This is a research instrument. It is needed by specialists in the most variegated areas. Only two such instruments

have yet been produced -- we have one at the Institute of Space Research and the other is at the Karl Zeiss Jena plant, where they are also analyzing the photographs made during the Rainbow space experiment. By the way, this instrument produces color images of much better quality than those obtained by ordinary color photography.

[Question] Your institute obligingly gave five of these multiband color photographs to "Ogonyek," so we could publish them for the first time. I wish you would comment on them in more detail.

Begin, if you will, with the picture printed on the magazine's cover. In my opinion, before this picture was taken only cosmonauts in orbit could see the fantastic beauty of deep space and the bright rainbow of the Earth's horizon.

[Ziman] You are undoubtedly right. This is the first time such a multiband color image of the Moon and the Earth has been printed. In this photograph, you see the real colors. The picture is actually very beautiful. The survey of the Moon and the night horizon was taken for the purpose of investigating the Earth's atmosphere and the camera's characteristics. In this experiment, the Moon was photographed through open space (as in the picture) and through the Earth's atmosphere.

During the Rainbow experiment, however, the basic attention was turned toward the Earth instead of objects in space.

From orbit, mountains actually have different colors from those in the photograph. Those are conditional colors that are used so scientists can detect the necessary details better. The photograph covers the southern part of the Fergana Valley, a considerable part of the Alayskiy Range, part of the Zaalayskiy Range, and a small segment of the Pamir Mountains. The region is notable for its complex structure. Numerous geological faults are visible in the picture. Separate types of geological formations are given different colors. Such pictures contain extremely valuable information for geologists and are of assistance in the search for useful minerals.

It is obvious that the mountaintops are covered with snow. The grayish threads of glaciers creep across the picture. The famous Fedchenko glacier is in the very corner of the photograph. This picture is a present for the geographers. It was used for comparison with the catalog of glaciers by scientists in the Laboratory of Aerospace Methods in Moscow State University's Geography Department. On the most detailed map of this section there are 27 glaciers, but thanks to this picture there are now 106.

This photograph also contains much valuable information for agricultural specialists. Sections with vegetation are seen in red. They can be used to find areas where cattle can graze in the mountain pastures.

/Question/ And what do you see on the picture of the Baykal region?

/Chesnokov/ This is the central part of the Baykal area, and this photograph also has conditional colors. It is important for the problem of preserving Lake Baykal's purity. Where the Selenga River flows into the lake, the water is cloudy. What is the river carrying into the lake? Sand and silt, maybe, or possibly products of manmade pollution? The specialists have yet to analyze this picture.

Look at the upper part of the picture. An enlarged fragment is printed alongside the main photograph. Specialists from Moscow State University's Geography Department think that by the colors in the picture it is possible to distinguish winter crops that have sprouted and plantings of grains, oats, potatoes, and sugar beets. They have different colors. Is it really possible to see sections as small as a single hectare? I do not have to tell you how much space photographs tell the specialists in agriculture.

Now, let us look carefully at the picture of the upper section of the Vilyuy River. The light-colored filament of the sandy beach, swamps, tiny lakes, and forests are clearly visible. The forest vegetation has its own range of colors. Large groups of spruce are blue-green, while the pines are bright green and the larches are greenish-brown. The dark spots are burned areas.

This photograph is both very interesting and of extraordinary importance for many branches of the national economy. The Rainbow experiment yielded the first multiband pictures of the permafrost area. Frost processes are clearly visible in the photograph.

The area in the photograph is very difficult to travel through -- in it there are many swamps and lakes. It is also very interesting for geologists.

This picture can help in the development and improvement of navigation on the Vilyuy. Actually, this river is the only way to carry heavy drilling equipment for the extraction of gas and oil into this region.

/Ziman/ We have only examined a couple of photographs, but it is already obvious how valuable they are to our country's national economy. As you see, space investigations have considerable real value.

The Rainbow experiment again demonstrated that the investigation of Earth from space is a complicated scientific and technical problem, for the solution of which it is necessary to unite specialists from the most diversified areas of science and technology. Only by joint, coordinated efforts can we fulfill the assignment given us by the 26th CPSU Congress: expand the research for the use of space means to study the Earth's natural resources.



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CSO: 8144/1546

## MOSCOW ORDER OF LABOR RED BANNER INSTITUTE OF STEEL AND ALLOYS

Moscow MOSKOVSKIY ORDENA TRUDOVOGO KRASNOGO ZNAMENI INSTITUT STALI I SPLAVOV in Russian 1973 pp 1-32

[Booklet, Izdatel'stvo Metallurgiya, 5000 copies]

[Text]

Manufacturers of modern equipment make greater and more varied demands of metal materials. Alloys are needed that operate at temperatures near absolute zero or exceeding 1000 to 1200°C, nonmagnetic alloys, various semiconductor, piezoelectric and ferroelectric materials. Higher and higher demands are presented to light and very light alloys, alloys for permanent magnets, corrosion resistant alloys that are not destroyed by the action of chemically aggressive media, nuclear radiation and compounds that radiate gamma-rays.

Achievements in the development of metallurgical processes (vacuum metallurgy, electroslag welding of metals and alloys, electron beam fusion, plasma metallurgy) and the successes of physics of metals opened up new possibilities in the utilization of steel and existing alloys for structural materials for modern industries. Obtaining especially pure metals and alloys, the use of new methods for processing metals by pressure and thermal treatment make it possible to achieve high strength properties and are the basis for creating new devices and machines.

In creating alloys to meet various requirements, in addition to traditional metals (iron, copper, nickel, aluminum, magnesium etc.), more and more such metals as titanium, vanadium, molybdenum,tungsten, cobalt and beryllium are used. Most various alloying components and admixtures are introduced into the alloy composition, while the stability of metals and alloys and the higher productivity of processes are achieved by improving existing arrangements of metallurgical production, and by the use of comprehensive mechanization and automation of metallurgical units and technological processes.

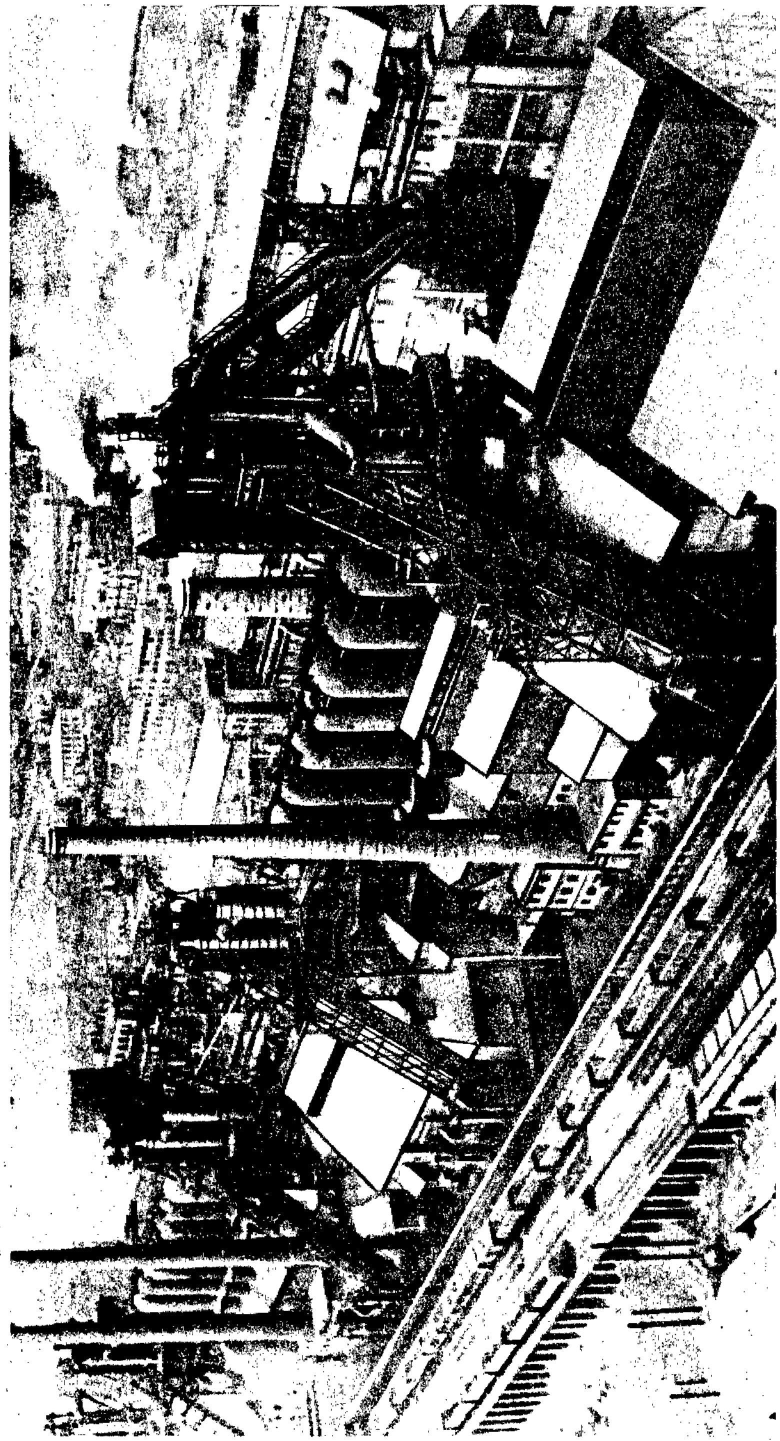
The search for more productive and efficient methods for manufacturing ferrous and nonferrous metals and alloys that need less capital investments and provide lower costs of production is an important national economic problem on the solution of which depends, to a considerable degree, the building of the material-equipment base of communism.

Students in the Institute of Steel and Alloys obtain the extensive physiochemical and mathematical preparation needed for mastering the science about metals, alloys and semiconductor materials, the theory and practice of modern methods of producing and processing ferrous, nonferrous and rare metals, and organizing the control of the processes and economics of metallurgical production.

The institute was first organized in 1918 as a metallurgical faculty of the Moscow Mining Academy, created in the difficult years of the civil war by a decree signed by V. I. Lenin, and was made into an independent educational institution in 1930.

At present, the Institute of Steel and Alloys is the leading vuz in the country for training engineering and scientific cadres and for research in the field of metallurgy and automation of production of ferrous, rare and radioactive metals, semiconductor materials, processing metals and alloys and the physics of metals. It has 8500 students of which more than 5000 are day students. Some 90 professors and doctors of science, including four academicians and corresponding members of the USSR Academy of Sciences and 287 lecturers and candidates of sciences, teach in 46 departments and in the science laboratories of the institute. Some 20 professors and instructors of the institute were awarded the high titles of winners of Lenin's bonuses and government bonuses.

The institute has one of the largest graduate study facilities for training candidates of sciences in the country--about 500 persons study in it. Every year, instructors and graduate students of the institute defend 5 to 7 doctor's dissertations and 100 to 120 candidate's dissertations in seven of the institute's consolidated scientific councils.



Scientists of the institute, with the participation of students, have solved a number of scientific-engineering problems of great importance to the national economy.

The Institute of Steel and Alloys is well-known abroad.

The People's Republic of Bulgaria, the Hungarian People's Republic, the Democratic Republic of Vietnam, the German Democratic Republic, the Chinese People's Republic, the Polish People's Republic, the Socialist Republic of Rumania, the Czechoslovak Socialist Republic, the Republic of Cuba, India, Indonesia, Ceylon, the Arabian Republic of Egypt, Morocco, Iraq, Guinea, Mali, Ghana--this is a list of countries whose representatives are studying or have already received higher education and candidates of science degrees at the Institute of Steel and Alloys.

There are constant scientific contacts of the institute with scientists abroad who lecture or make reports there while visiting the Soviet Union. Fundamental textbooks and monographs by professors of the institute were translated abroad.

The institute has the following faculties:

metallurgy of ferrous metals and alloys;

metallurgy of nonferrous and rare metals and alloys;

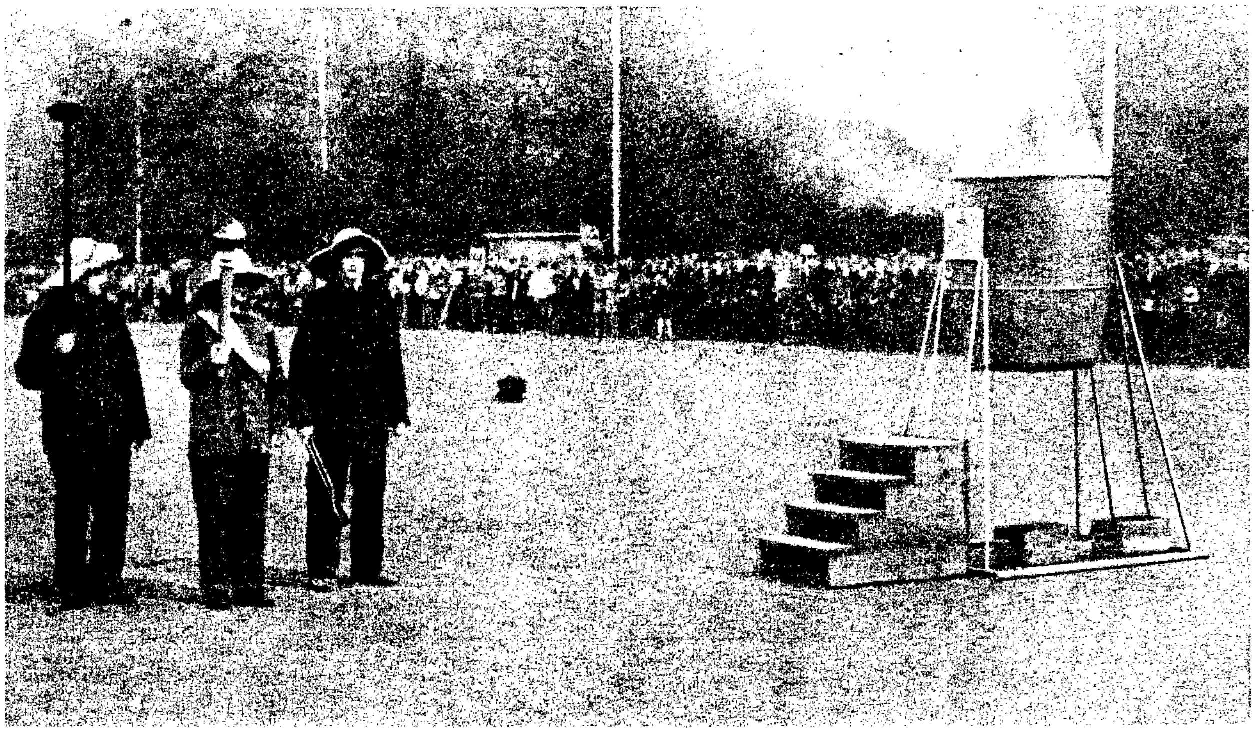
physio-chemical;

semiconductor materials and devices;

night school;

raising the skill of metallurgical specialty instructors in vuz of the country;

raising the skill of managers, engineers and technicians in the metallurgical industry.



Faculty of Ferrous Metals and Alloys Metallurgy

Faculty dean--professor, doctor A. M. Mikhaylov.

The following professors and doctors of sciences work in the departments of the faculty: Ye. V. Abrosimov, I. I. Ansheles, I. G. Astakhov, N. P. Bannyy, D. I. Vasil'yev, Ye. F. Vegman, D. I. Gabriel'yan, Honored Activist of Science and Engineering of the RSFSR; M. A. Glinkov, V. A. Grigoryan, G. Ya. Gun, S. V. Yemel'yanov, V. T. Zhadan, Hero of Socialist Labor B. N. Zherebin; Honored Activist of Science and Engineering of the RSFSR V. I. Zalesskiy; B. M. Zlobinskiy, V. Yu. Kaganov, N. I. Korobov, V. A. Krivandin, A. V. Krupin, Yu. V. Kryakovskiy, I. B. Kumanin; winner of the government bonus L. I. Levi; V. I. Mitkalinnyy, A. M. Mikhaylov, G. N. Oyks, Ya. M. Okhrimenko; Hero of Socialist Labor, Honored Activist of Science and Engineering of the RSFSR and winner of government bonus P. I. Polukhin; V. P. Polukhin, I. N. Potapov, academician of the Academy of Sciences of the Kirghiz SSR S. M. Popov, Honored Activist of Science and Engineering of the RSFSR A. N. Pokhvisnev; V. A. Romenets, S. B. Stark, N. M. Fedosov, A. B. Chelyustkin, Honored Activist of Science and Engineering of the RSFSR S. I. Sharov; Yu. S. Yusfin; winner of the government bonus, Honored Activist of Science and Engineering of the RSFSR V. I. Yavoyskiy; and A. I. Kholodov.

The faculty graduates engineers in the following specialties:

1. Automation and Comprehensive Mechanization of Metallurgical Production (0635)

Engineers of this specialty are trained in departments of ore-thermal processes, steel metallurgy, electric metallurgy of steel and ferrous alloys and the manufacture of rolled stock and pipes.

To acquire the skill of an engineer in the field of automation and comprehensive mechanization of production, students, on the basis of extensive training in mathematics and physics, study areas related to the theory of automatic controls and facilities for automating production.

The final stage of training consists of studying technological installations to be controlled, systems for automatic control, their design, installation and operation. Successful work in the field of automation requires extensive study of the technology of production and the processing of metals and alloys in the liquid and solid states.

The specialty is represented at the faculty by two further specializations:

1) automation and technology of processes for manufacturing ferrous metals;

2) automation and technology of rolled stock manufacture.

Students who selected the first specialization acquire the skills of engineers-metallurgists on comprehensive mechanization, automation and servicing one of the following:

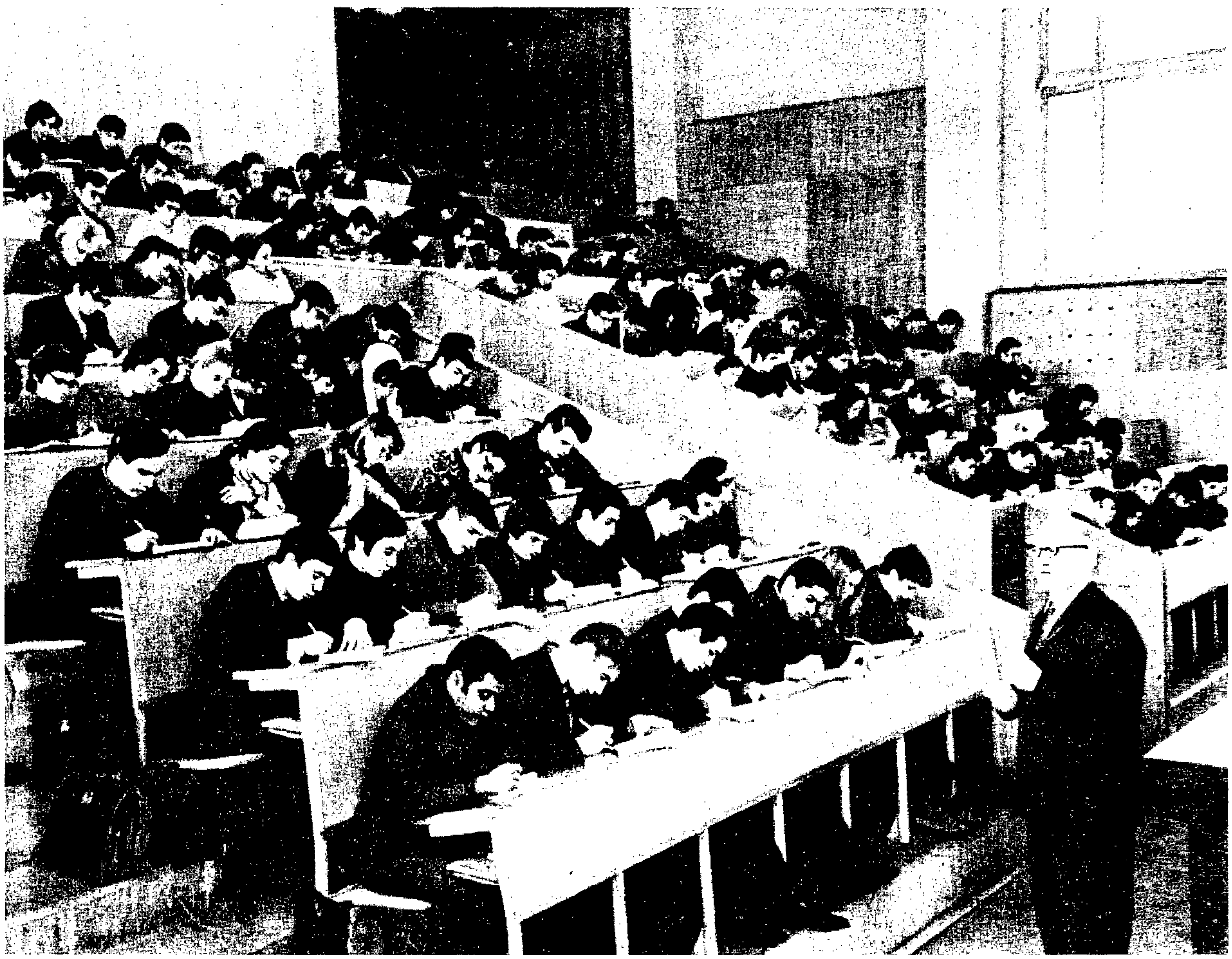
--production of cast iron;

--production of steel in open-hearth furnaces and converters;

--electrometallurgical production of high quality steels and alloys.

The second specialization trains engineers for work on automation, comprehensive mechanization and servicing of rolling and drawing mills that manufacture solid rolled shapes, rolled sheets, wire, pipes and other rolled products.

Engineers trained in these specializations supervise the installation and adjustment of automatic systems and their operation, as well as do work in central plant laboratories, and design and research institutes.



2. Metallurgy of Ferrous Metals (0401)

This faculty is represented by three specialties:

1) metallurgy of cast iron;

2) metallurgy of steel;

3) electric metallurgy of steel and ferrous alloys.

Engineers are trained in metallurgy of cast iron in the ore-thermal processes department (manager of the department is Hero of Socialist Labor professor, doctor B. N. Zherebin).

Specialists in steel metallurgy are trained in the steel metallurgy department (manager of the department is winner of the government bonus, Honored Activist of Science and Engineering of the RSFSR, professor, doctor V. I. Yavoyskiy).

Engineers in electric metallurgy of steel, specializing in the manufacture of high quality steel and ferrous alloys, are trained in the department of electric metallurgy of steel and ferrous alloys (manager of the department is professor, doctor V. A. Grigoryan).

Training of engineers-metallurgists in all three specialties is based on studying chemistry, physical chemistry, mathematics, crystallography and physics.

Students gain practical experience at various installations and machines in the laboratories of the departments.

Graduates of the institute in these specialties work in metallurgical shops, design organizations and research institutes.

3. Thermal Equipment and Automation of Metallurgical Furnaces (0403)

Engineers in this specialty are trained in the department of theory and automation of furnaces (manager of the department, Honored Activist of Science and Engineering of the RSFSR, professor, doctor M. A. Glinkov).

Three specializations are provided at the faculty:

1) metallurgical furnaces;

2) automation of thermal processes;

3) physical methods for purifying industrial gases.

For the first specialization, students study thermal physics, and the theory of calculating and designing metallurgical furnaces. Graduates of this specialty work as thermal engineers in metallurgical shops, plant laboratories and design institutes.

Students who selected automation of thermal processes as their specialization receive extensive training in the disciplines of the electrical equipment cycle and applied electronics.

Students in the physical methods for purification of industrial gases department study properties and laws of motion of aerosols and specialize in calculating and designing dust-collecting and gas-purification apparatus. This is a new specialty and was introduced for the first time in 1966. Other metallurgical vuz in the Soviet Union do not graduate specialists in this field.

4. Casting of Ferrous and Nonferrous Metals (0404) with a specialty "casting of ferrous metals"

Engineers in this specialty are graduates in the technology of the casting processes department (manager of the department is professor, doctor A. M. Mikhaylov).

Training in casting is done on the basis of engineering disciplines of metallurgical and physical-metallurgy cycles. Students study physio-chemical bases for casting metals and alloys, the technology of casting, equipping and designing casting shops, and the problems of mechanizing and automating casting.

Casting engineers work in machine building and metallurgical plants, in design and research institutes, on improving the technology for manufacturing ingots in one-time-only use molds, in permanent molds, under pressure, by the centrifugal method and special kinds of casting.

5. Physio-chemical Investigations of Metallurgical Processes (0405)

This faculty has two specializations:

1) metallurgy of ferrous metals;

2) cybernetics of metallurgical processes.

Theoretical training in these specializations is given in the physio-chemical faculty, while special training is given in the faculty of metallurgy of ferrous metals and alloys by assigning students individually to research groups guided by leading professors of the departments.

Students are trained in the "metallurgy of ferrous metals" specialization in the departments of ore-thermal processes and metallurgy of steel and they study higher mathematics, experimental and theoretical physics and physio-chemical cycle disciplines (inorganic chemistry, physical chemistry, the theory of metallurgical processes, physio-chemical investigations of metallurgical systems etc.).

A compulsory part of the study plan is scientific research work in laboratories of special departments.

Engineers specializing in the "cybernetics of metallurgical processes" are trained in the engineering cybernetics department (manager of the department is professor, doctor S. V. Yemel'yanov). They work on developing, creating and introducing automatic systems for operational planning and control of complicated complexes (shop, plant, industrial sector). To solve such problems the students master modern mathematics, technology, economics and organization of metallurgical production, computer techniques and study the theory of automatic controls.

This is a new specialization; it was introduced in 1967. Other metallurgical vuz of the Soviet Union do not train specialists in this field.

6. Processing Metals by Pressure (0408)

The faculty has four specializations:

1) rolling and drawing ferrous and nonferrous metals;

2) forge-stamping production;

3) molding of special alloys;

4) pipe production.

Engineering training for these is the same and is based on disciplines of flow mechanics, the study of physical and mechanical properties of metals and alloys, as well as the theory and technology of various types of metal processing.

Rolling and forge-stamping production engineers are trained in the department for processing metals by pressure (manager of the department is professor, doctor A. V. Krupin).

Graduates of the institute in this specialty work in rolling and drawing shops of metallurgical plants, plant laboratories and scientific research institutes, as well as in the system of machine building and instrument building industries.

Students in the third and fourth specialties are trained in the plastic deformation of the special alloys department (manager of the department is Honored Activist of Science and Engineering of the RSFSR, Hero of Socialist Labor, winner of the government bonus, professor, doctor P. I. Polukhin).

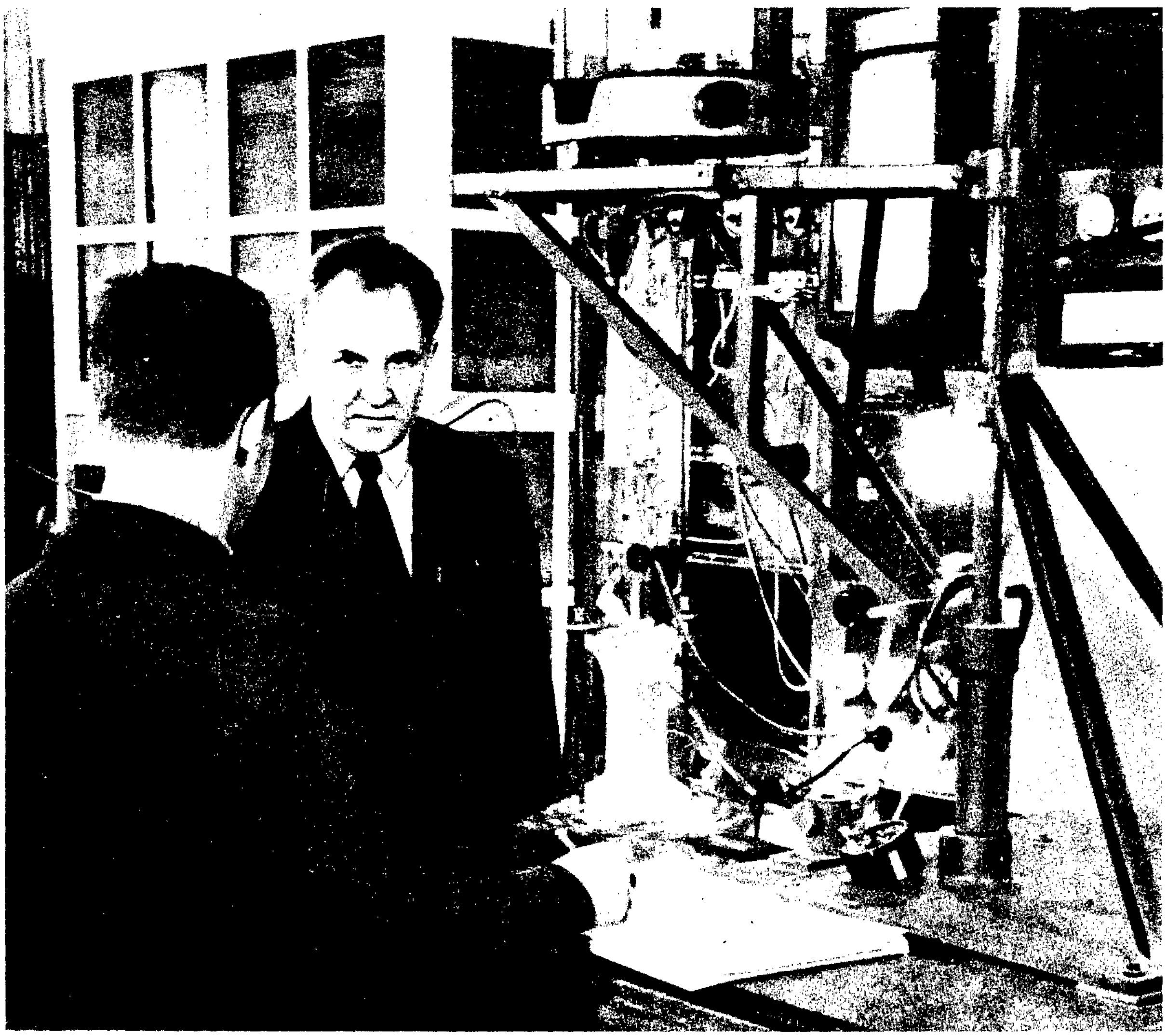
Upperclassmen in this department do a compulsory complex of scientific research work in the laboratory of optical methods for investigating stresses and deformations.

7. Economics of the Metallurgical Industry (1708)

Engineers are trained in the department of economics and the organization of production in the metallurgical industry (manager of the department is professor, doctor V. A. Romenets) in two specializations:

1) economics and organization of ferrous metallurgy;

2) economics and organization of nonferrous metallurgy



Students specialize in the field of calculating the economic efficiency of new equipment, economic evaluation of changes in equipment, the technology and organization of production, the determination of efficient ways for technical progress and planning concrete measures for developing equipment in metallurgy.

Training specialists in this specialty is based on the study of the disciplines of the technical and engineering cycles, planning the national economy, industrial statistics, economics of the industry, organization and planning of a metallurgical enterprise, and scientific organization of labor and management. All disciplines are studied on the basis of higher and specialized mathematical training, including the study of computers.

Graduates in this specialty work in the field of economics, organization and planning of new equipment and the technology of metallurgical production at metallurgical plants, associations, design and scientific research institutes and laboratories.

Such specialists will be trained for the first time.

Faculty of Metallurgy of Nonferrous and Rare Metals and Alloys

Dean--professor, doctor S. S. Kiparisov.

The progress of modern science and engineering depends to a great extent on the state of production of nonferrous, rare and radioactive metals. Specialists in this area are trained at the faculty of metallurgy of nonferrous and rare metals and alloys. The specialty includes the technological cycle of producing nonferrous, rare and radioactive metals, automating processes for their production and metallophysical investigations of the metals and their alloys, as well as obtaining special materials by the powder metallurgy method.

The following work in the departments of the faculty: academician A. A. Bochvar, as well as professors and doctors of sciences: A. A. Abramov, A. I. Burovoy, A. V. Vanyukov; winner of Lenin's bonus, N. P. Galkin; I. T. Gul'din, Yu. M. Golutvin, M. V. Zakharov, V. Ya. Zaytsev, A. N. Zelikman, M. D. Ivanovskiy, S. S. Kiparisov, M. A. Kolenkova, B. G. Korshunov, S. F. Kuz'kin, A. I. Layner, V. S. Lovchikov; winner of Lenin's bonus, G. A. Meyerson; I. I. Novikov; Honored Activist of Science and Engineering of the RSFSR, S. I. Polkin; D. S. Starodubtsev.

Engineers are trained in the following specialties.

1. Enrichment of Minerals (0204)

The department of enriching nonferrous and rare metal ores (manager of the department is doctor A. A. Abramov) trains specialists in enriching

ores of nonferrous and rare metals, as well as in the technology and use of flotation agents.

Along with studying general and special subjects in physics, chemistry, mathematics, electronics, electrical engineering, geology and mining, students are taught comprehensive extraction and separation of dispersed nonferrous and rare metals from ores by physio-chemical (flotation), physical (gravity, electric separation, radiometric sorting) and other methods. A great amount of attention is given to the practice of carrying out scientific investigations in the fields of infrared spectroscopy, neutron absorption measurements, physio-chemical flotation etc.

Graduates of the institute work as engineers at enriching factories of mine-metallurgical combines and in scientific research and design institutes.

2. Metallurgy of Nonferrous Metals (0402)

This faculty has four specializations:

1) metallurgy of heavy nonferrous metals;

2) metallurgy of light nonferrous metals;

3) metallurgy of rare metals;

4) metallurgy of radioactive metals.

Engineers in these specialties are trained in the department of heavy nonferrous metal metallurgy (manager of this department is professor, doctor A. V. Vanyukov); department of light nonferrous metal metallurgy (manager of this department is doctor I. T. Gul'din), department of metallurgy of rare, radioactive metals and powder metallurgy (manager of this department is professor, doctor S. S. Kiparisov).

The training of specialists in all four specialties is based on studying the disciplines of the chemical cycle and theoretical metallurgy. Students study nuclear physics, radio-chemistry and methods of nonferrous metals analysis, physics and chemistry of nuclear reactors, the metallurgy of nonferrous, rare and radioactive metals and other disciplines.

3. Casting of Ferrous and Nonferrous Metals (0404) with specialization in "casting of nonferrous metals and alloys"

Engineers in this specialty are trained on the basis of engineering disciplines of metallurgical and physical metallurgy cycles. Students study the physio-chemical bases of smelting metals and alloys, theoretical bases of casting, technology of casting ingots and irregularly shaped castings, and equipping and designing casting shops.

Graduate engineers work is the shops of aviation, shipbuilding, instrument building, machine building and metallurgical industry plants, in design and research institutes on developing the technology of manufacturing castings in permanent molds, under pressure, in one-time-only molds and other special casting methods.

4. Physio-chemical Investigations of Metallurgical Processes (0405)

Students in this department specialize in powder metallurgy (metal-ceramics), which is a new method for manufacturing products from metallic and nonmetallic powders and their mixtures thus obtaining materials with special properties.

The engineers are trained in the department of metallurgy of rare, radioactive metals and powder metallurgy on the basis of disciplines of the chemical cycle, physical metallurgy and theoretical metallurgy.

Engineers in this specialty work in scientific research institutes, plant laboratories, in shops of machine building plants and other enterprises.

5. Physical Metallurgy Equipment and Technology of Thermal Treatment of Metals (0407)

Engineers in this specialty are trained in the department of physical metallurgy of nonferrous and rare metals and alloys (manager of the department is professor, doctor I. I. Novikov).

Besides basic physical and physio-chemical disciplines, students in this specialty study physical metallurgy and thermal treatment of nonferrous, rare and radioactive metals, the physics of metals, X-ray diffraction analysis and mechanical testing. They are taught modern methods of investigating the structure of nonferrous and rare metals by means of electron microscopy and X-ray structural analysis, measurement of mechanical and other various properties at high and low temperatures, in vacuum and under other conditions.

Graduates of the institute work in research institutes, plant laboratories and thermal treatment shops. They work on creating alloys with given properties: high strength light alloys based on aluminum, magnesium and titanium, heat resistant alloys based on nickel, niobium and molybdenum, and alloys with special properties.

6. Processing Metals with Pressure (0408)

Theoretical training in this specialty is given in accordance with an engineering program cycle for the faculty of metallurgy of nonferrous and rare metals and alloys. The special training is given by corresponding special departments of the institute.

7. Automation of Metallurgical Production (0635)

Engineers of this specialty are trained in the department of automation of production of nonferrous and rare metals (manager of the department is doctor V. A. Ivanov).

Students who select this specialty also receive, in addition to general engineering training, training in disciplines of automating production processes--the theory of automatic control, measuring devices, electronics, computers and automation facilities.

Graduates work in plants, scientific research and design institutes.

8. Economics of Metallurgical Production (1708)

This specialty is represented at the faculty by specialization in "economics and organization of nonferrous metallurgy." Engineers are trained in the faculty of economics and the organization of production in the metallurgical industry.

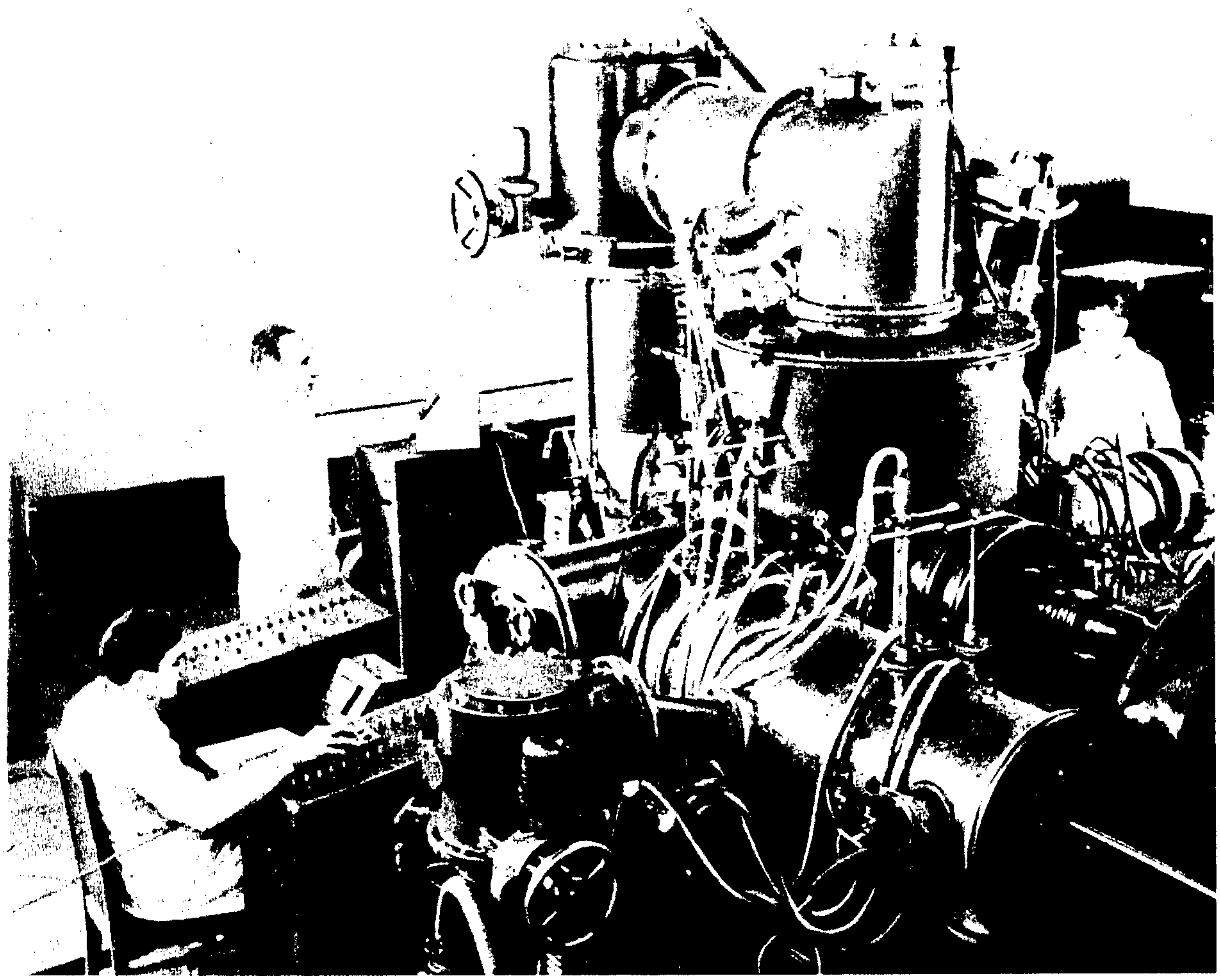
Students specialize in the field of planning and organization of production and labor at enterprises, improving systems and methods of control, as well as in the field of technical-economic planning--economic evaluation of new equipment, technology and organization of production, its efficient disposition and finding other ways for raising the efficiency of metallurgical production.

Graduates work in metallurgical plants, in associations, design and scientific research institutes and laboratories.

Specialists of this kind are being trained for the first time.

Physio-chemical Faculty

The dean is professor, doctor Ye. I. Mozzhukin.



The latest achievements of physics, chemistry, electronics and other precise and applied sciences are used widely in the production of ferrous and nonferrous metals and in their further ductile and thermal treatments. Therefore, metallurgical and machine building enterprises and scientific research institutes require extensively not only engineers-technologists, but also research engineers who could study and improve existing technological processes, as well as develop and introduce new processes based on the modern achievements of science. The physio-chemical faculty graduates such specialists.

Students of this faculty receive theoretical training in mathematics, experimental and theoretical physics, physical chemistry, theoretical bases of metallurgical processes and protection of metals against corrosion, as well as obtain knowledge in the field of metallurgical technology and physical metallurgy, the production of precision alloys and high temperature materials. They also master modern methods for investigating physio-chemical processes, properties and the structure of metals and alloys.

The following noted professors and doctors of sciences work in the departments of the faculty: Yu. S. Avraamov, D. K. Belashchenko, M. L. Bernshteyn; Honored Activist of Science and Engineering of the RSFSR, corresponding member of the USSR Academy of Sciences, winner of the government bonus, V. P. Yelyutin; N. P. Zhuk, A. A. Zhukhovitskiy, Z. I. Ivanova, A. Ye. Kadyshevich; winner of the government bonus, I. N. Kidin; winner of the government bonus, B. G. Livshits; Honored Activist of Science and Engineering of the RSFSR, A. N. Krestovnikov; M. A. Maurakh, Ye. I. Mozzhukin, Yu. A. Pavlov, I. V. Paisov; S. I. Filippov; Honored Activist of Science and Engineering of the RSFSR, Ya. S. Umanskiy; P. S. Titov and Yu. Skakov.

The faculty graduates engineers in the following specialties:

1. Physio-Chemical Investigations of Metallurgical Processes (0405)

This specialty has three specializations:

1) metallurgy of ferrous metals;

2) high temperature materials;

3) corrosion and protection of metals.

Engineers of the first specialty are trained in the department of physical chemistry (manager of the department is professor, doctor A. A. Zhukhovitskiy) and in the department of the theory of metallurgical processes (manager of the department is professor, doctor S. I. Filippov).

Research and technological engineers in the field of the production and use of high temperature materials are trained in the high temperature materials department (manager of the department is corresponding member of the USSR Academy of Sciences V. P. Yelyutin).

Research and technological engineers in the field of research and production of corrosion resistant alloys and fighting corrosion of metals under industrial conditions are trained in the corrosion and metal protection department (manager of the department is lecturer, candidate of engineering sciences M. N. Fokin.

Disciplines for the above specializations are higher mathematics, experimental physics and a number of disciplines of the physio-chemical cycle: inorganic chemistry, the theory of metallurgical processes, physio-chemical research of metallurgical systems etc.

The scientific research work of students in the laboratories of the departments occupies an important place in their training.

2. Physics of Metals (0406)

Engineers in this specialty are trained in four specializations:

1) physics of metals;

2) metal-physics of high strength alloys;

3) precision alloys;

4) plastic deformation of metals and alloys.

Specialists in the physics of metals are trained in the X-ray diffraction analysis and physics of metals department (manager--professor, doctor Yu. A. Skakov) and in the theoretical physics department (manager--professor, doctor A. Ye. Kadyshevich).

Engineers in this specialization work in laboratories that study the microstructure and atomic structure of alloys and are used for investigating the latest physical methods (nuclear magnetic resonance, ultrasonics etc.).

The purpose of the specialization in metal physics of high strength alloys is to train engineers to create new high strength materials and improving methods for their processing based on studying the laws governing the strengthening of metals and alloys. This training is done in the department of the physical metallurgy of steel and high strength alloys.

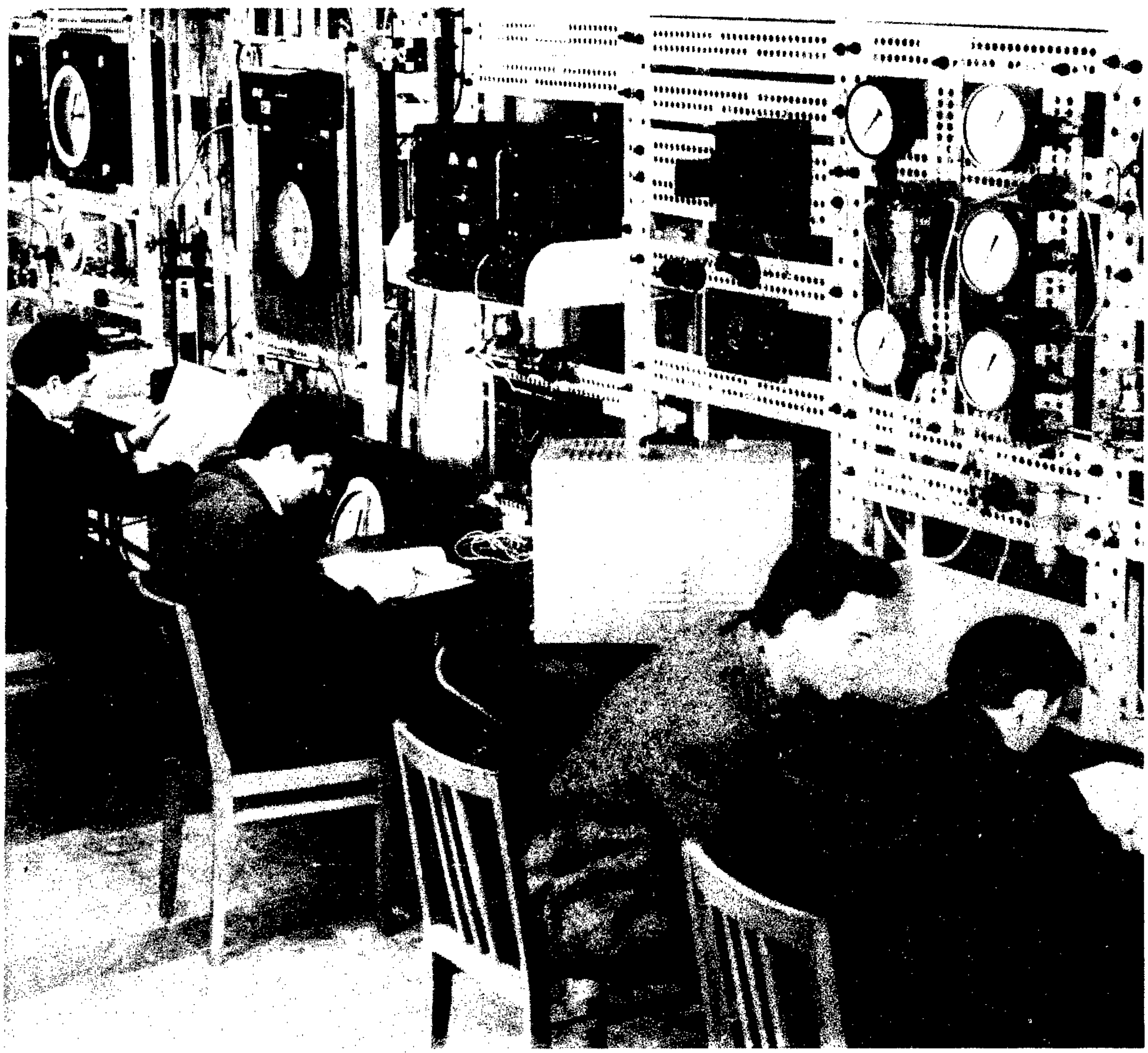
Precision alloy engineers are trained in the metallography department (manager--winner of the government bonus, doctor B. G. Livshits). Using laws established by the physics of metals, graduates of the institute work on creating new alloys with special physical characteristics (magnetic and electrical) and improve existing alloys.

The plastic deformation of special alloys department trains specialists in the plastic deformation of metals and alloys, whose problem is improving methods for processing metals by pressure on the basis of the modern theory of plasticity.

The basic disciplines of this specialty are higher mathematics, experimental and theoretical physics, and the disciplines of the physics cycle such as metallography, physical metallurgy, X-ray diffraction analysis, physics of metals, physical and mechanical properties of metals etc.

3. Physical Metallurgy, Equipment and Technology of Thermal Treatment of Metals (0407)

Engineers in physical metallurgy and thermal treatment of ferrous metals and alloys are trained in the department of physical metallurgy of steel and high strength alloys (manager--winner of the government bonus, professor, doctor I. N. Kidin.



Students who selected this specialty study extensively metallography, physical metallurgy and the physics of metals, while their theoretical knowledge is strengthened in modern laboratories of physical metallurgy, high speed mechanical testing, and electrothermal, chemical-thermal processing. The main discipline for this specialty is thermal and thermomechanical treatment of metals and alloys.

Graduates of the physio-chemical faculty of the institute work as research engineers in shop and plant laboratories, research institutes and experimental production facilities in metallurgical and machine building industries.

Faculty of semiconductor materials and devices

The dean is professor, doctor Yu. S. Avraamov.

Modern radioelectronics and electronics in general (including quanta and superhigh frequency), direct conversion of heat and solar energy into electrical energy, complex computers and control machines are unthinkable without semiconductors and dielectric devices.

The operation of these devices is based on complex physical processes in solids. Their manufacture requires materials which certain strictly regulated properties. Most frequently required are materials of extreme purity and great structural perfection in the form of monocrystals, thin films, epitaxial layers etc.

The creation of special materials with new in principle properties and possibilities makes it possible to develop new semiconductor devices.

This faculty trains specialists who have the knowledge necessary for developing and obtaining the above-enumerated materials and devices.

The following professors and doctors of sciences work in the department of the faculty: B. A. Agranat, V. N. Adrianov, G. V. Aleksenko, V. D. Afanas'yev, S. S. Gorelik, Ye. A. Zhemchuzhina, V. V. Krapukhin, S. A. Medvedev, L. A. Firsanova, M. P. Shaskol'skaya; doctor of physical and mathematical sciences, Ye. S. Trekhov; doctor of physical and mathematical sciences, A. A. Blistanov.

Laboratories of the faculty are equipped with modern equipment for obtaining monocrystals; for zone melting of metals, semiconductors and dielectric materials; for obtaining and investigating thin films; precision apparatus for investigating physical, physio-chemical and other properties, the structure of materials and the physical properties of semiconductor devices.

Graduates of this faculty qualify as electronic equipment engineers.

Engineers at this faculty are trained in the following specialties.

1. Technology of Special Materials for Electronic Equipment (0643)

Complex processes for obtaining materials for semiconductor devices and quanta oscillators require from future specialists fundamental knowledge in the fields of quantum physics and chemistry of elements and their compounds; theoretical and technological bases of processes for obtaining extremely pure metals and semiconductors; the synthesis of materials with given properties; and obtaining perfect monocrystals and extremely thin films.

For this purpose students study higher mathematics, quantum physics and chemistry, the physics and metallurgy of semiconductors, special methods for determining microscopic amounts of impurities; vacuum equipment and other engineering and special disciplines.

Graduates of this specialty work in scientific research institutes, design bureaus and at enterprises that develop new semiconductor materials and the technology of their manufacture.

Engineers in this specialty are trained in the following directions:

1. Obtaining extremely pure metals and semiconductors for new fields of science and engineering.

2. Obtaining semiconductor elements and compounds with given properties for manufacturing semiconductor devices.

3. Producing microelectronic elements--thin films and epitaxial layers of metals and semiconductor materials for manufacturing active and passive elements in radio-electronic circuits in film and solid-circuit technology of modern microelectronics.

4. Investigating physio-chemical characteristics of semiconductors.

Training in the indicated specialization is given in the department of physical chemistry and technology of semiconductor materials and superpure metals (manager--professor, doctor V. V. Krapukhin).

5. Electro-chemical and surface processing of materials for electronic equipment.

Students in this field are trained in the corrosion and protection of metals department.

2. Semiconductors and Dielectrics (0604)

Developing semiconductor and dielectric materials requires extensive study of the laws concerning the relationship between the properties of materials and their crystalline structure, the nature of chemical relationships, chemical and phase composition, structural defects etc.

On the basis of these laws recommendations are developed for the technological principles for obtaining and alloying the recommended materials and the various actions on them (radiation, deformation, thermal treatment) to obtain the optimal properties.

Students in this specialty study higher mathematics, experimental and theoretical physics, general and physical chemistry, crystallography, physics and physical metallurgy of semiconductors, physics of solids, physics and technology of semiconductor devices, methods for investigating their structure, engineering and special disciplines.

Graduates work in plant laboratories and scientific research institutes and at enterprises that manufacture materials and devices for electronic equipment.

Engineers in the "semiconductors and dielectrics" specialty are trained in the following directions:

1. Producing and investigating semiconductor and dielectric crystals with given properties.

These engineers are trained in the semiconductor material technology department (manager--professor, doctor S. S. Gorelik) and the crystallography department (manager--lecturer, doctor of physical and mathematical sciences, A. A. Blistanov).

2. Producing and investigating properties of magnetic semiconductors (ferrites).

Students study the theory of ferromagnetism, the technology of producing ferrites, the effect of their composition on properties, the principles of developing new magnetic materials and devices using ferrites.

Such engineers are trained in the semiconductor material technology department.

3. Producing electronic devices using piezo- and ferroelectric materials.

These students specialize in the field of research of the physical properties of nonlinear dielectrics--ferroelectric materials that find progressively wider application in various fields of electronic equipment.

The students get special training in the physics department (manager--doctor of physical and mathematical sciences, Ye. S. Trekhov).

4. Investigating structures of semiconductors and dielectrics.

Students specializing in this field study modern methods of structural analysis--X-ray diffraction, electrongraphic, neutrongraphic, electron microscopy, optical microscopy methods (infrared and polarization) and other methods--as applied to semiconductors and dielectrics.

Engineers in this specialty are trained in the semiconductor material technology department.

5. Investigating physical properties of semiconductors.

Special attention in this specialization is given to studying the nature of the physical properties of semiconductors, methods and apparatus for investigating the physical parameters of semiconductors and developing, on this basis, some types of devices.

Such specialists are trained in the department of semiconductor electronics and physics of semiconductors (manager--professor, doctor S. A. Medvedev).

3. Semiconductor Devices (0629)

The faculty prepares specialists in microelectronics and semiconductor devices (transistor diodes, controlled switches, photosensitive devices, semiconductor quanta oscillators etc.).

The complexity of physical phenomena that determine the properties of semiconductor devices and their parameters requires from future specialists extensive knowledge in the field of physics of semiconductors and semiconductor devices and skill in understanding the processes that determine their operation in circuits.

A special feature in training specialists in devices and microelectronics at the Moscow Institute of Steel and Alloys is the broad training in the field of semiconductor material technology and methods for their investigations. Moreover, in courses on electrical equipment, radio equipment, automatic controls and computers, future specialists are given the knowledge necessary for extensive learning in special disciplines, as well as for their practical work when they graduate from the institute.

Graduates in this specialty work in scientific research institutes and design organizations that develop semiconductor devices, semiconductor functional circuits and elements of microelectronics, and at plants of the semiconductor industry and microelectronics.

Direct training of such specialists is given in the department of semiconductor electronics and physics of semiconductors.

## Night School

The institute conducts a night school for students who continue to work in production.

The dean of the night school faculty is lecturer, candidate of engineering sciences. L. Ya. Kozlov.

The Moscow night school faculty trains engineers in the following specialties:

1) physics of metals (0406);

2) physio-chemical research of metallurgical processes (0405);

3) metallurgy of nonferrous metals (0402);

4) semiconductors and dielectrics (0604);

5) technology of special materials for electronic equipment (0643);

6) processing metals by pressure (0408).

Training engineers in the enumerated specialties is given in the departments of the respective daytime faculties.

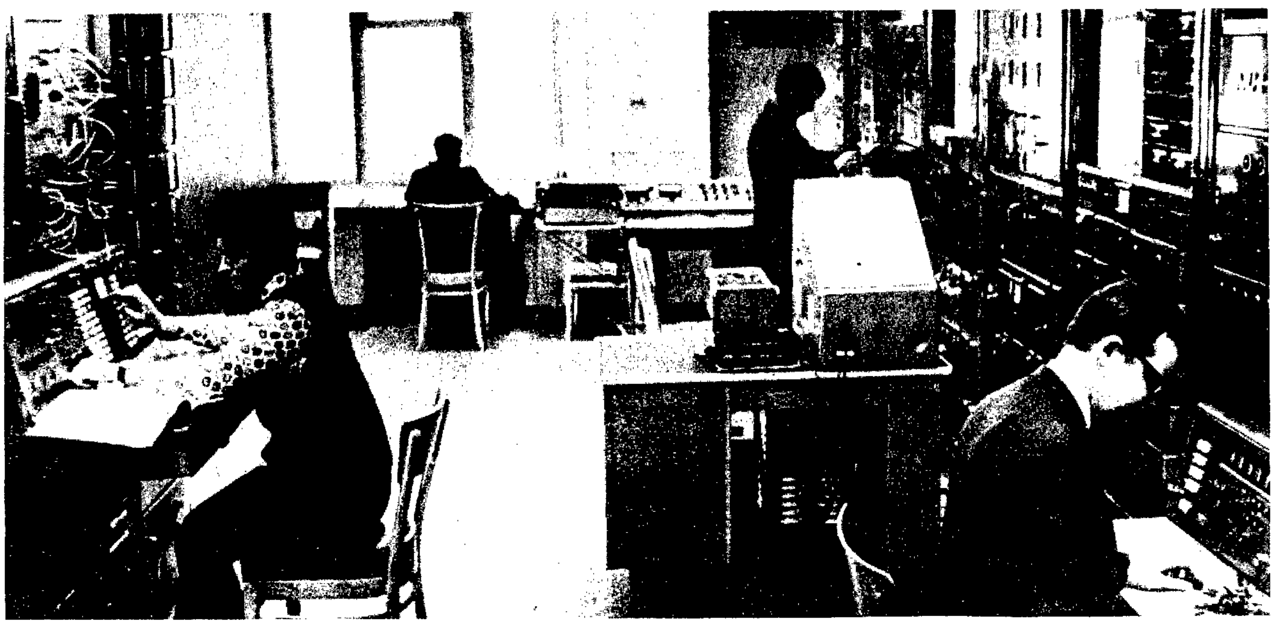
## Training Methods

The training of engineers is accomplished in accordance with individual study plans approved for the institute, with great attention being given to developing in students habits of independent work and research. Theoretical knowledge obtained in lectures are strengthened in laboratories where the work is not only of a study nature, but provides for doing research within the area of activity of the respective departments.

General scientific and general engineering training of engineers graduated by the institute are given by the following departments: higher mathematics (manager--professor, doctor V. A. Trenogin), theoretical mechanics (manager--academician of the Academy of Sciences of the Kirghiz SSR, professor, doctor S. M. Popov), resistance of materials (manager--professor, doctor G. Ya. Gun), analytical chemistry (manager--professor, doctor Z. I. Ivanova), general machine building and machine parts (manager--professor B. K. Kucherov), electrical equipment (manager--professor, doctor G. V. Aleksenko), labor safety (manager--professor V. N. Brinza) and general chemistry (manager--professor, doctor B. G. Korshunov) etc.

A number of the institute's departments use programmed teaching machines that monitor the knowledge of students and their independent training. Practical experience is acquired by students when they pass through production practice at metallurgical and machine building plants of the country and in Scientific research institutes. Practice begins after the completion of the second year and its goal is to acquaint students with production, prepare them for studying general technological courses and, later, special technological courses. Students work in staff jobs after studying special disciplines in the fourth year and during the period of prediploma practice.

The total term of study is 5 years at the faculties of metallurgy of ferrous metals and alloys, metallurgy of nonferrous and metals and alloys, semiconductor materials and devices, while the total term of study is 5.5 years at the physio-chemical faculty. Training in the institute is completed by writing a thesis or by doing a thesis research project which are defended by students in government examination commissions. In a number of cases, theses have research sections and are done on subjects proposed by plants. Thesis research work is done by students who have demonstrated aptitudes for research activity. As a rule, they represent a continuation of the scientific work of the students done in the process of studies, as well as on his own time. Students report the results of their scientific work at departmental student scientific seminars conducted by the student scientific society imeni D. K. Chernov, as well as at annual student scientific-engineering conferences. Each year, the institute publishes abstracts of scientific papers done by students. The best papers are issued in handbook form and are published in periodicals.



Devices and installations designed with the participation of students and manufactured in experimental-production shops of the institute, were exhibited in zone and republic exhibitions of student scientific work. For successes in developing the scientific work of students, the institute

was awarded the Certificate of Honor of the VDNKh; eight students were awarded VDNKh medals for participating in the republic exhibition and the exhibition dedicated to the 50th anniversary of the VLKSM.

At the last all-union competition of student scientific work, students of the institute were awarded three medals for scientific work in the field of physio-mathematical sciences and metallurgy; five students were awarded certificates of the USSR Ministry of Higher and Secondary Education. According to the results of the Second All-Union Competition of Student Work on Social Sciences, dedicated to 50th anniversary of the VLKSM, four papers received certificates of the first degree and three papers--certificates of the second degree by the Moscow City Committee of the VLKSM, the Moscow City Committee of the Trade Union of Educational Workers of Higher Education and Scientific Establishments. Broad possibilities for attracting students to scientific research work and converting it into a component part for training engineers are provided by developments in the scientific research departments of the institute on contracts by industries.

The institute represents a large scientific center in which research is done, along with staff workers, by teachers, postgraduate students and students and numbers 2500 persons. Besides departmental scientific laboratories, the institute has problem-solving and industrial scientific laboratories, including pure metals, metal compounds and semiconductor materials laboratory, permanent magnet laboratory, high temperature materials laboratory, optical methods for the study of stresses laboratory, microelectronics laboratory, metals and alloys laboratory, a laboratory for the automation of operational planning and control in ferrous metallurgy, and a laboratory for the production of steel, forgings and castings.

The volume of scientific research on contracts with metallurgical and machine building plants and organizations amounts to over 2 million rubles annually.

In the last 5 years, the All-Union Scientific-Engineering Information Center entered over 400 works of great scientific and practical interest completed at the institute, in the government register while institute staff workers obtained 165 author's certificates.

Postgraduate students are selected mainly from graduates of the institute who actively participated during their training in scientific research work and demonstrated their interest in social affairs. In this connection, the departments maintain ties with graduates working in production and scientific research institutes. Part of graduates are accepted for postgraduate work on the recommendation of the Scientific Council.

Material, Welfare, Rest and Recreation Conditions of Students

Daytime students get a government stipend of 35 to 45 rubles per month in the first to fourth years inclusive and 45 to 50 rubles per month in the senior year. Since September 1972 the stipend was increased in accordance with the decree of the CC CPSU and the USSR Council of Ministers.

The stipend starts the first year on the basis of the results of the entrance exams and in the following years--on the basis of the results of examinations taking into account in all cases the material conditions of the students.

Students sent by enterprises for training in the institute get a stipend that is 15 percent higher than the usual government stipend. Excellent students have their stipends raised by 25 percent and they are paid regardless of the material condition of the student.

Students who combine excellent work with scientific and social work get Lenin stipends and stipends of academician M. A. Pavlov.

The student city of the institute, where out of town students live, has a dining room and a sports hall. The institute is building new dormitories for 1000 places each, as well as a sports complex with a swimming pool and a stadium.

The medical personnel of the health center in the institute monitors the health of the students and sanitary conditions.

During the summer, the trade union organization provides students with passes for rest and recuperation in rest homes, sanatoria and tourist camps.

The institute has its own sports and rest camp at Pitsunda on the shores of the Black Sea.

During summer vacations, students organize construction detachments for working at shock construction sites of the USSR and in fraternal socialist countries. Two students of the institute--A. Timoshenko and I. Zhulina, were awarded medals "For Labor Valor."

The institute has a university of culture (rector--academician of the Kirghiz SSR, S. M. Popov), a student club, youth clubs, artistic groups among whom are many winners in city amateur exhibits, a choral group, an institute choir, winners in all-union and international competitions of amateur films of the MISfil'm [expansion unknown] a cinema studio, and a student theatrical group.

Physical education is given to students in the department of physical education and sports (manager--lecturer, candidate of phylosophical sciences, K. M. Dedov) as part of their compulsory studies in physical culture in 22 sections of sports improvement in the department and the student sports club.

The institute occupies the third place among the Moscow vuz, and for several sports--the first and other prizes in handball, chess, skating, classical wrestling, underwater swimming, sport orientation, and bow and arrow shooting. One team of the institute is among the first in the USSR in tourism. Two sportsmen of the institute are members of the combined Olympic team of the USSR.

In the last 5 years, over 5000 certified sportsmen and over 300 trainers and umpires were trained.

Training of Matriculant Students and Regulations for Acceptance at the Institute

1. Preparatory department--for workers and members of kolkhozes who have at least 1 year of practical experience, as well as for demobilized soldiers from the Soviet army. Applications are received by the admittance commission from 1 October to 10 November inclusive.

2. Correspondence preparatory courses--for workers and members of kolkhozes with a working experience of not less than 2 years; applicants desiring to take the correspondence preparatory courses should present to the institute the following documents: an application, a notarized copy of the secondary education certificate, a recommendation from the place of work, two photos 3 x 4 cm, an extract from the work book and a receipt for tuition payment.

3. Night school preparatory courses. Applications are accepted by the education department of the institute from 10 September to 1 October inclusive. Classes are held three times a week at night starting on 1 October.

4. Sunday lectures. Leading professors and instructors give lectures on the most complex sections of mathematics, physics and chemistry with an analysis of problems formerly given at entrance examinations. They start in October. Entrance free.

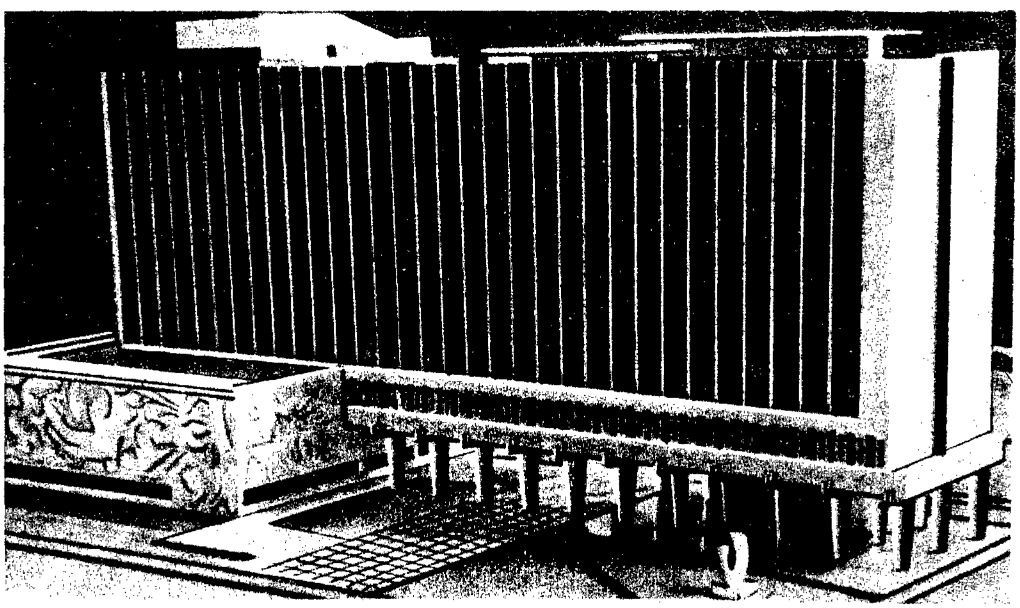
5. Physio-mathematical school--for seniors in secondary schools. Studies start in October. Applications are received by the dean of the physio-chemical faculty from 1 August to 30 September inclusive.

6. Forty-day preparatory courses--from 20 June to 31 July inclusive for workers and kolkhoz members sent to the institute.

7. Preparatory courses for workers in Zaporozh'ye, Bekabad, Orsk, Ust'-Kamenogorsk and Cherepovets.

Open-house days and physio-mathematical Olympics are held twice a year.

Oral consultations are held before the entrance exams starting 1 July.



USSR citizens up to 35 years old who have completed their secondary education are accepted as freshmen in the institute. The night school faculty has no age limit.

Application for acceptance is sent to the rector of the institute stating the faculty and specialty.

The following should be attached to the application:

- document on education (original);
- recommendation for entering the vuz;
- medical report (form No 286);
- 6 photos 3 x 4 (pictures without hats);
- a copy of the labor or kolkhoz book (for production workers).

Upon arriving at the institute, the student must present in person: passport, military certificate or registration certificate.

Applicants present recommendations given by party, Komsomol, trade union and other public organizations, managers of enterprises, establishments, organizations, administrations of kolkhozes, while graduates of secondary schools present recommendations from heads and public organizations of schools. Those demobilized from the Soviet army or navy present recommendations from the military command.

Applications for day departments are received from 20 June to 31 July inclusive; entrance exams are held from 1 August to 20 August inclusive. Applications to night school are accepted from 20 June to 20 August inclusive and entrance exams are held from 21 August to 31 August inclusive.

All applicants must take the following entrance exams: for daytime faculties of ferrous metallurgy and alloys, metallurgy of nonferrous and rare metals and alloys, and for the night faculty: mathematics (written), physics (oral), chemistry (oral), Russian language and literature (written),

For the faculty of physio-chemical and semiconductor materials and devices: mathematics (written), mathematics (oral), physics (oral), Russian language and literature (written).

Applicants awarded a gold (silver) medal on graduating from secondary school or who completed a special secondary school with a certificate of excellence, take mathematics exams (written) at faculties of metallurgy of ferrous metals and alloys, metallurgy of nonferrous and rare metals and alloys, and at the night faculty, mathematics exams (written) are taken at the physio-chemical and semiconductor materials and devices faculties . On receiving grade "five" matriculating students are freed from any further entrance examinations.

The following are accepted at the institute without entrance examinations:

a) participants in the Great Motherland War who have a certificate of excellence from a secondary school or have been awarded a gold (silver) medal on completing a secondary school, or who have completed a special school with a certificate of excellence;

b) reservists from the Soviet army and navy, troops and organs of the Committee of Government Security at the USSR Council of Ministers, troops and organs of the ministries of internal affairs of union republics, officers and very urgent military service personnel who have completed higher military or civil education;

c) persons who completed day, night and correspondence preparatory departments established in accordance with decree No 681 of the CC CPSU and the USSR Council of Ministers of 20 August 1969 and who have passed graduation examinations successfully.

In obtaining positive evaluations in entrance examinations, the following are outside the competition:

a) participants in the Great Motherland War;

b) reservists from the Soviet army and navy, troops and organs of the Committee of Government Security at the USSR Council of Ministers, troops and organs of the ministries of internal affairs of the union republics, officers and very urgent military service personnel who completed secondary schools;

c) persons who completed technical schools with excellent grades and have a secondary education, who work in their specialty and are entering the vuz without interrupting their production work in a related specialty.

In the competition there are included in the first priority production leaders who have at least 2 years of practical experience and are sent to the vuz for full time studies directly by an enterprise and other organizations in accordance with decree No 1099 of the USSR Council of Ministers of 18 September 1959.

Advantages in competition selection are held by person who have at least 2 years of practical experience, as well as reservists who served at least 2 years in the army.

In the night faculty, first priority is given to persons who work in a specialty or related specialty to that selected in the higher educational institute and are sent by enterprises and organizations in accordance with decree No 729 by the CC CPSU and the USSR Council of Ministers of 3 September 1966.

END

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